pp experiments at LHC
ATLAS

Pawel Brückman de Renstrom

for the Polish ATLAS Community

(IFJ PAN & AGH UST)

AGH

AGH University of Science and Technology

ATLAS in Poland

Institutions: IFJ PAN & AGH UST

Participants (in FTE's):

19.5 staff, 5 PhD students, 4.5 support

Main contribution:

MoU: SCT+TRT+TDAQ (~1 MCHF)

M&O ~0.21 MCHF/year (not incl. Upgrade)

~700 shifts/year + 7.5 FTE of support

Main responsibilities:

Hardware/Operation: SCT HV PS, TRT DCS, TDAQ

Software/Analysis: HL Trigger, ID Alignment, SM physics, tau physics, HI physics

Financing (MNiSW & NCN):

Currently: ~1.5 MPLN/year (~0.4 MCHF/year x-change rate!)

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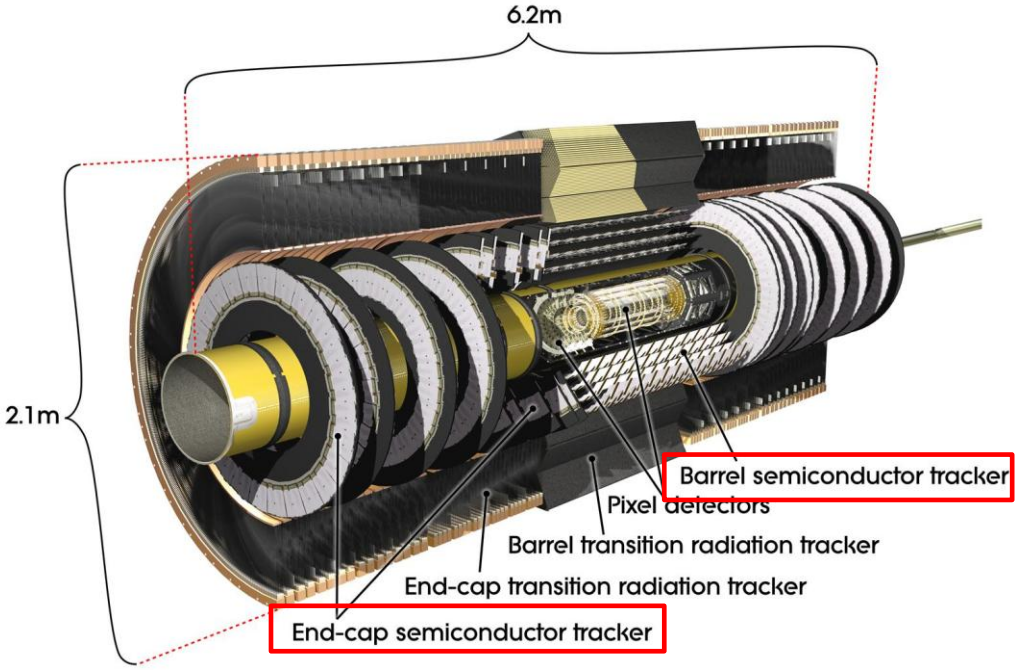
Contribution to detector design & construction
(~1 MCHF + FTE's over 1998-2006)

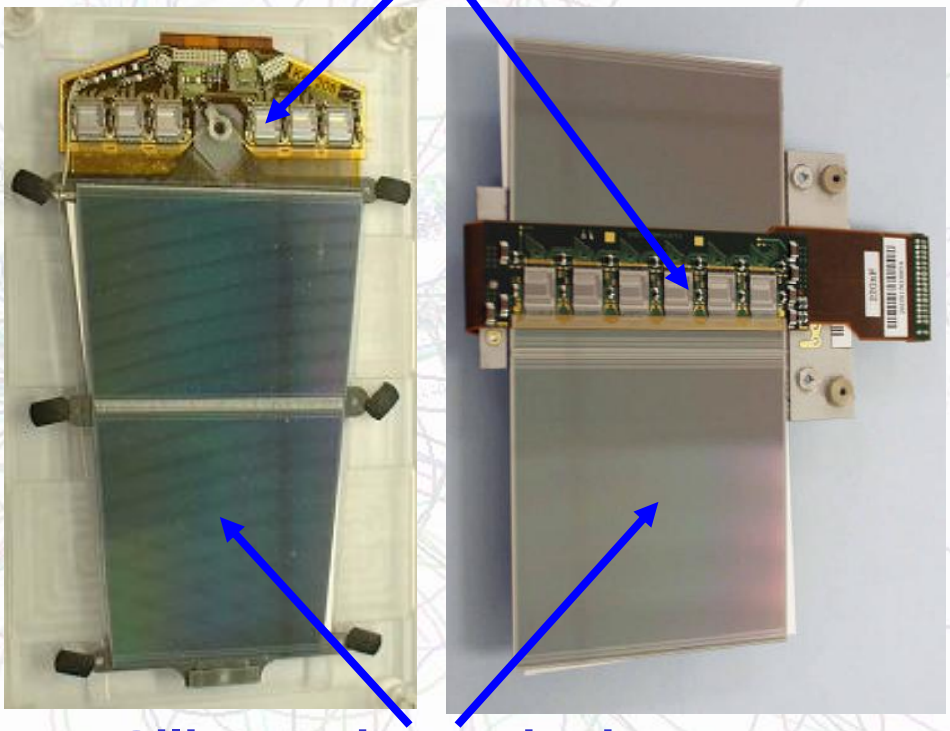
- Design of the front-end VLSI chip for the Semiconductor Tracker (SCT) and detector integration
- SCT power supply system construction, maintenance and operation
- Design and implementation of the TRT Detector Control System (DCS) and Gas Gain Stabilisation system
- Contribution to the ALFA detector (~25kCHF)
- R&D towards the Inner Tracker Upgrade for SLHC

Cracow in SCT (SemiConductor Tracker)
middle part of ATLAS Inner Detector

The ATLAS Inner Detector:



Readout ASICs
(Application Specific Integrated Circuits)



Silicon microstrip detectors

Complete SCT apparatus:

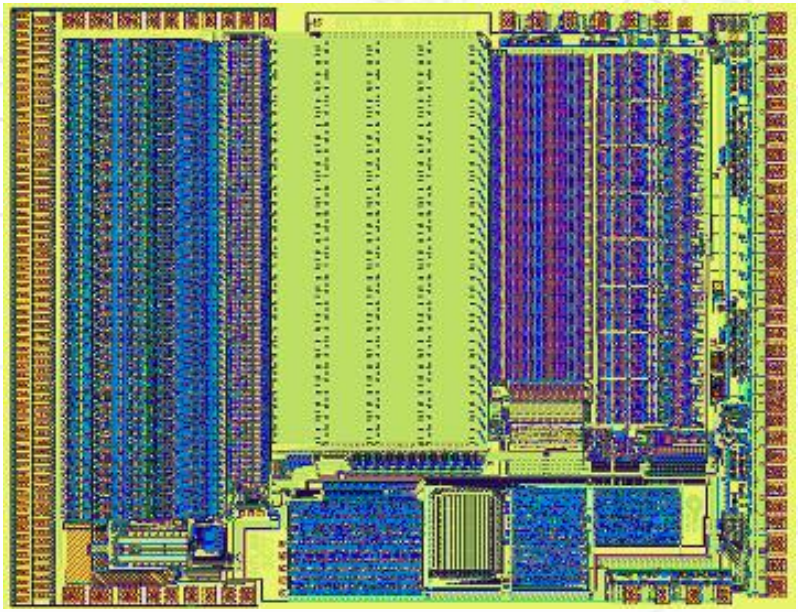
four barrels and 2x9 disks of double-sided silicon ministrips

4088 modules ~50 000 ASICs ~6 000 000 readout channels ~60 m^2 of silicon

Design of the frond-end VLSI chip for the Semiconductor Tracker and detector integration

❑ **Design of the ABCD3T ASIC for readout of silicon microstrip detectors**

(CERN, AGH & INP Kraków, U. Geneva)



128 front-end channels

2 levels of data buffering

Data derandomization and zero supression

Radiation hardness up to 10 Mrad

❑ **Burn-in and acceptance tests of readout hybrids for SCT modules**

Hybrid substrates produced by Cicorel (Switzerland)

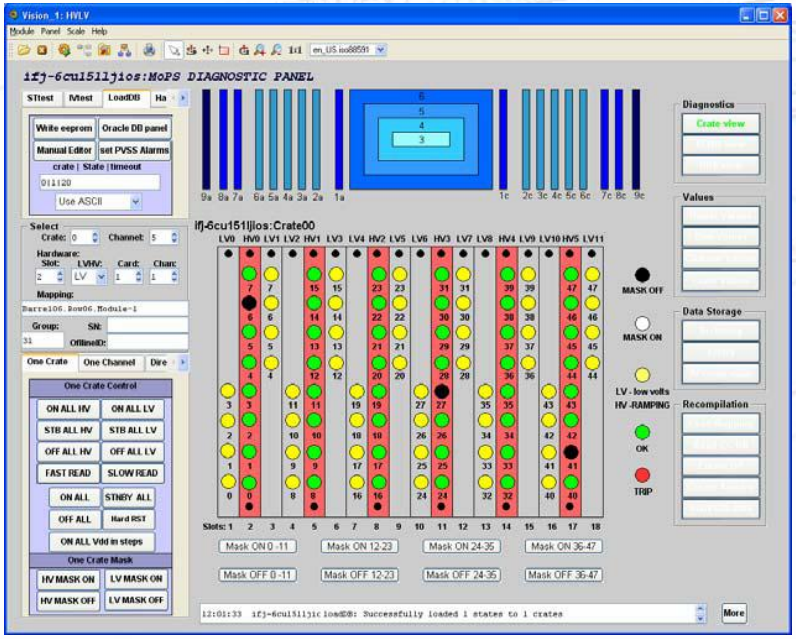
Pre-tested ASICs assembled in Hybrid S.A. (Switzerland)

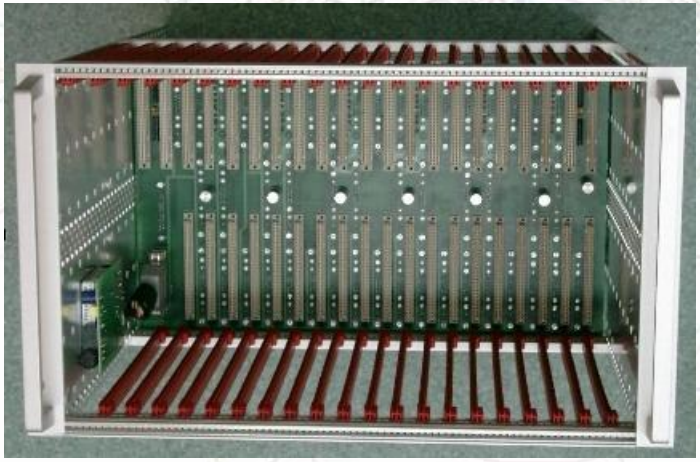
Burn-in tests and acceptance tests of 750 hybrids performed in AGH - laboratories of the Faculty of Physics and Applied Computer Science

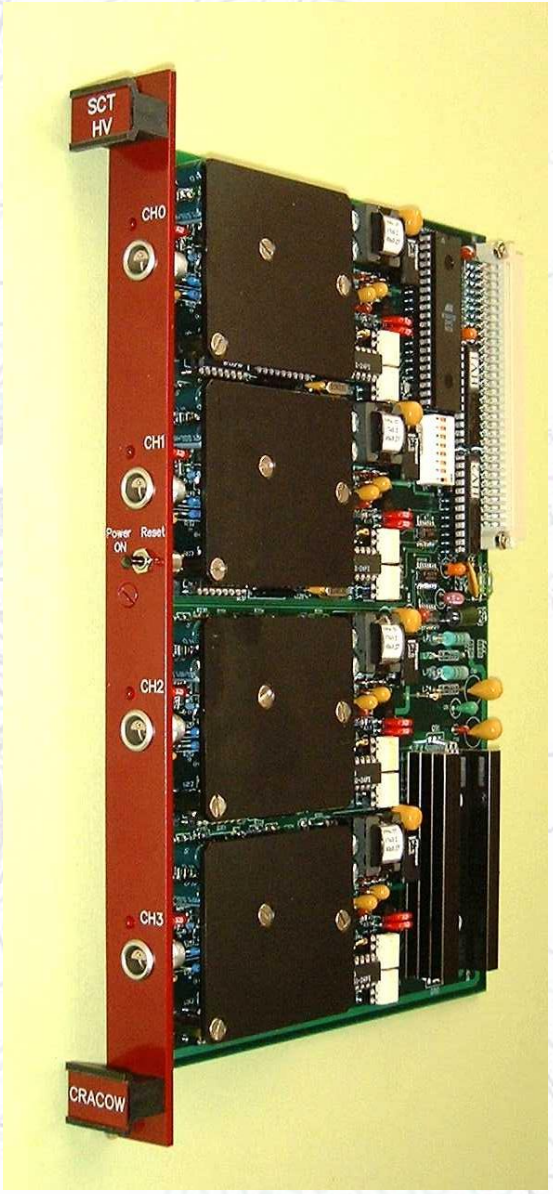
SCT PS construction and operation

(400 kCHF ; 1-3 FTE/year)

- Design, construction and maintenance of the HV power supply system + firmware (4088 channels),
- Design and construction of the common LV/HV backplanes and crate controllers (88 pcs)
- Maintenance of the DCS system covering the control of LV and HV PS of the SCT.

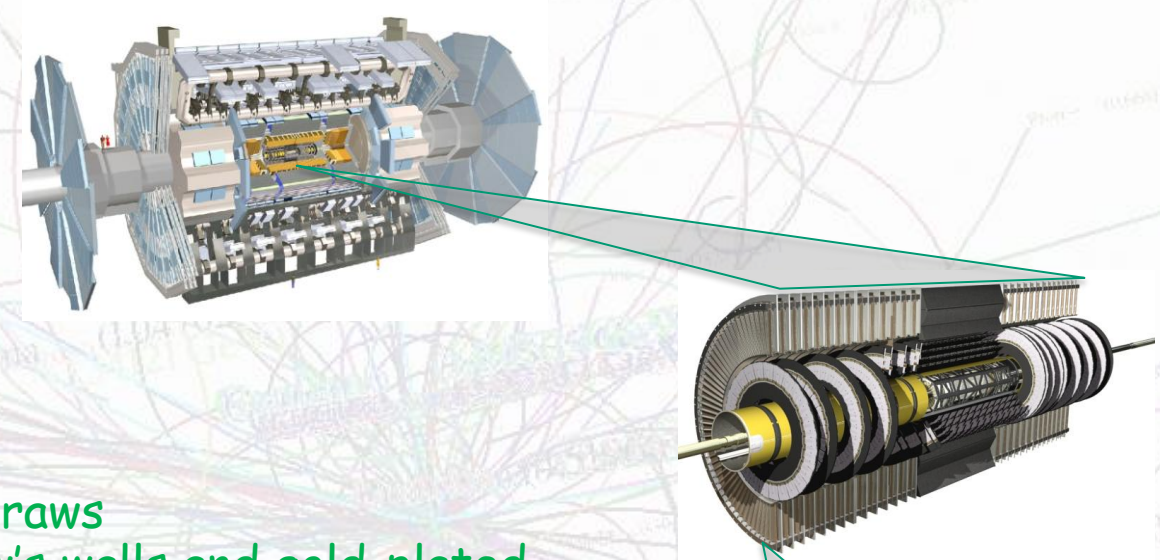






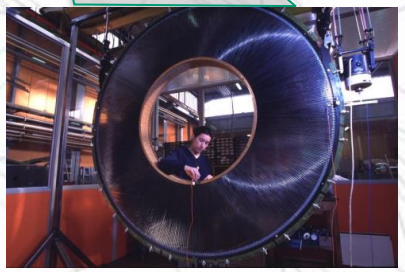
Cracow in TRT (Transition Radiation Tracker)
outermost part of ATLAS Inner Detector
tracking (quasi continuous) + pion/electron separation

…consists of ~300 000 straws (proportional counters)
with polypropylene radiator layers between them allowing electron identification.



What TRT needs to operate:

- ❑ stable active gas mixture to fill straws
- ❑ high voltage biasing between straw's walls and gold-plated tungsten wire
- ❑ stabilization of gas gain – drifts of active gas pressure, composition and local straws temperature by correcting HV bias
- ❑ distribution of low voltage power to front end readout electronics boards
- ❑ cooling of electronics readout boards, straws and power cables
- ❑ monitoring temperatures of different structures inside detector

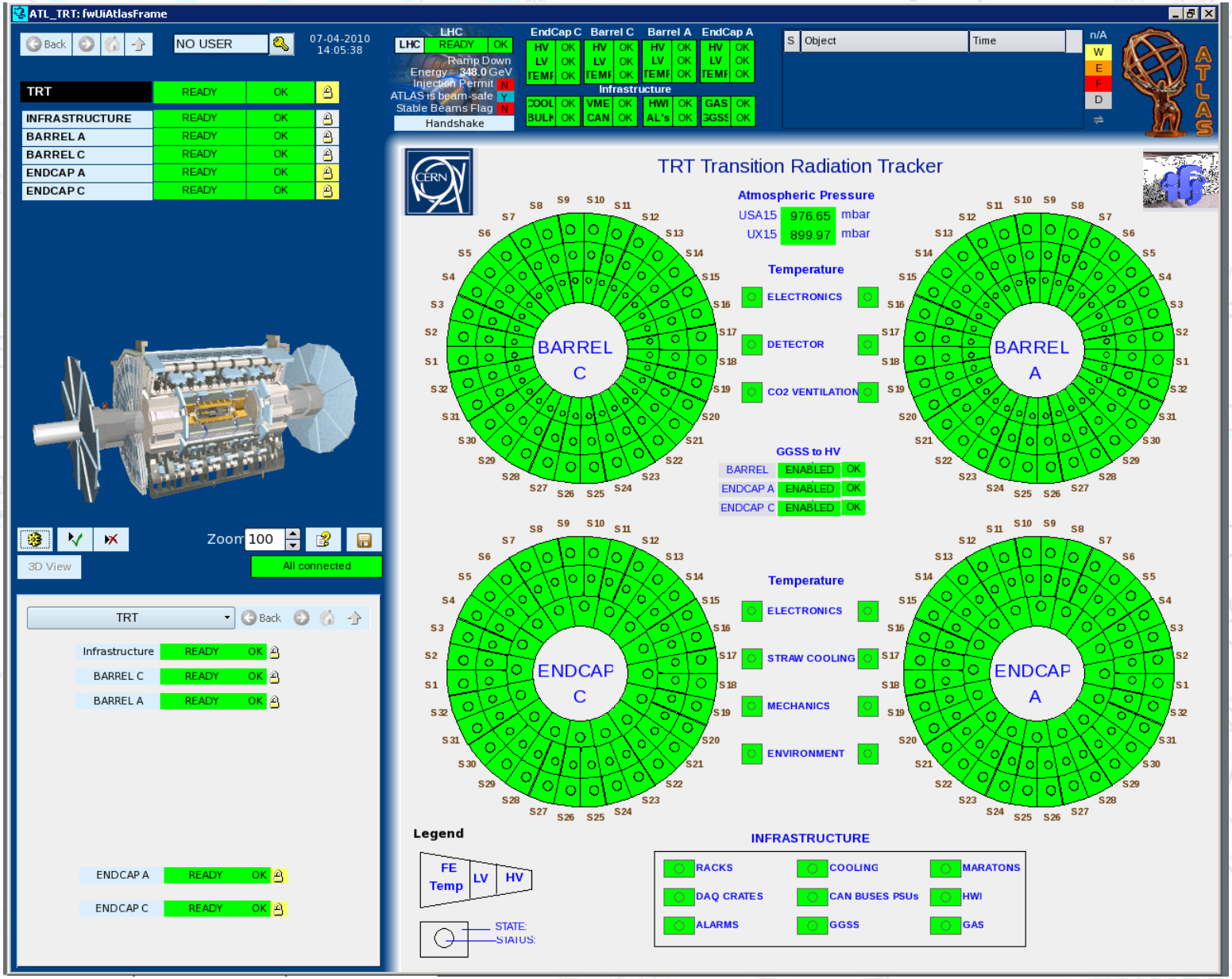


Major contribution to the TRT
(400 kCHF ; 3-5 FTE/year)

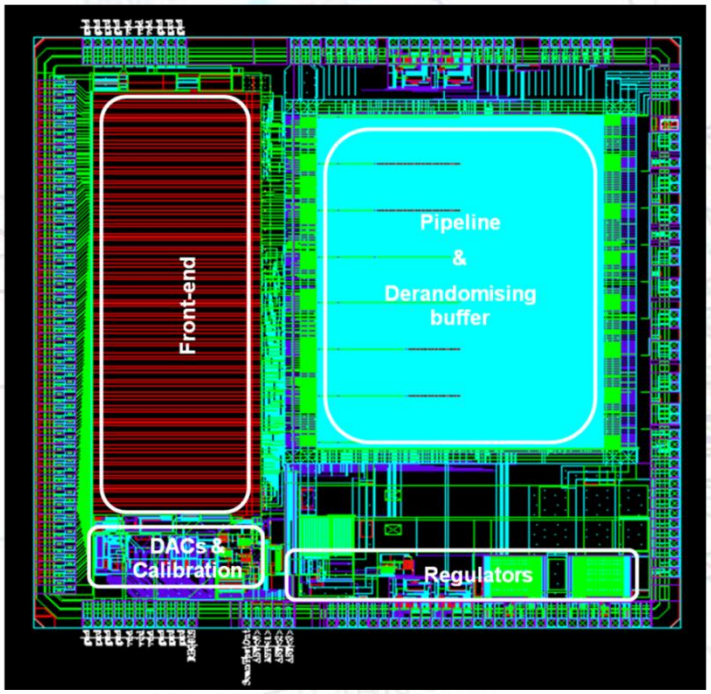
- Participation in project from pre-ATLAS times (RD-6) h/w + s/w contribution (tests of electronics + beam tests of prototypes)
- Membership in 'TRT project office' (managing structure during construction and installation)
- Design and implementation of Detector Control System (DCS) - responsibility solely of the Cracow team.
  - 11 computers, HV& LV power system, temperature +gas composition+environmemt monitoring
- Contribution to the design and construction of gas system
  - Important autonomous part – Gas Gain Stabilisation System
- Important contribution to development of the TRT LV & HV PS systems
- Participation in debugging and commissioning in the assembly area and after installation underground
- Preparation to long 2013-2014 shutdown and upgrades of the TRT auxiliary systems

Major responsibility: theTRT DCS

Graphical User Interface to TRT DCS
Overview of whole TRT detector (green – means OK.)



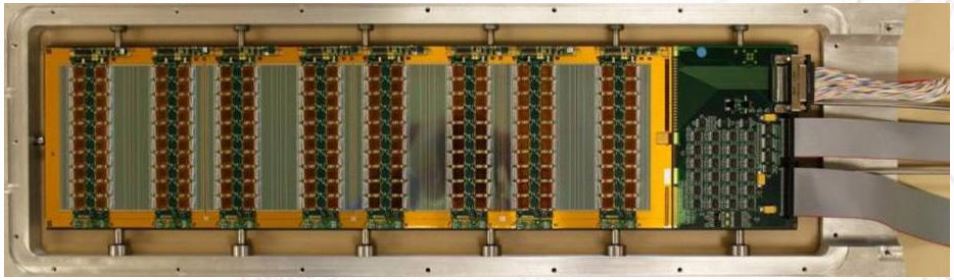
R&D towards the Inner Tracker Upgrade for SLHC



- **Design of the ABCN-25 ASIC for readout of silicon microstrip detectors.**

(CERN, AGH Kraków, U. Geneva, U. Penn)

The ASIC serves as a test vehicle for extensive program of module development for the Inner Tracker Upgrade.



- **Development of alternative powering schemes for tracking detectors (SLHC-PP project)**

Prototype stavelet (built at RAL) equipped with 160 ABCN-25 ASICs with modules powerd serially.

Contribution to software & operation

2011 shifts: Control Room 216/125, Remote 466/418,
Support FTEs 7.63/7.39

- TRT DCS expert (24/7 - 'on call') watch during data taking seasons (8-9 months in 2009-2011)
- Maintenance of the DCS (h/w and s/w + computers)
- High LevelTrigger area expert shifts
- ID and Trigger DAQ CR and Remote shifts
- LBCF & LAr/Forward Detector shifts
- ALFA TDAQ implementation and expert maintenance
- Inner Detector alignment design, implementation and expert maintenance
- Delivering 2-3% of the ATLAS computing resources via Tier2 and Tier3 Grid sites.

Contribution to physics program preparation and data analysis

- B-physics potential
- Higgs and SUSY discovery potential
- Tau reconstruction and identification
- $Z \rightarrow \tau\tau$ cross section measurement
- W physics ($W \rightarrow e\nu$ x-sec., $W \rightarrow \tau\nu$ obs., etc.)
- Heavy Ion program: analysis of Pb-Pb data
- ALFA - Absolute Luminosity For ATLAS
- AFP - ATLAS Forward Physics (diffraction)

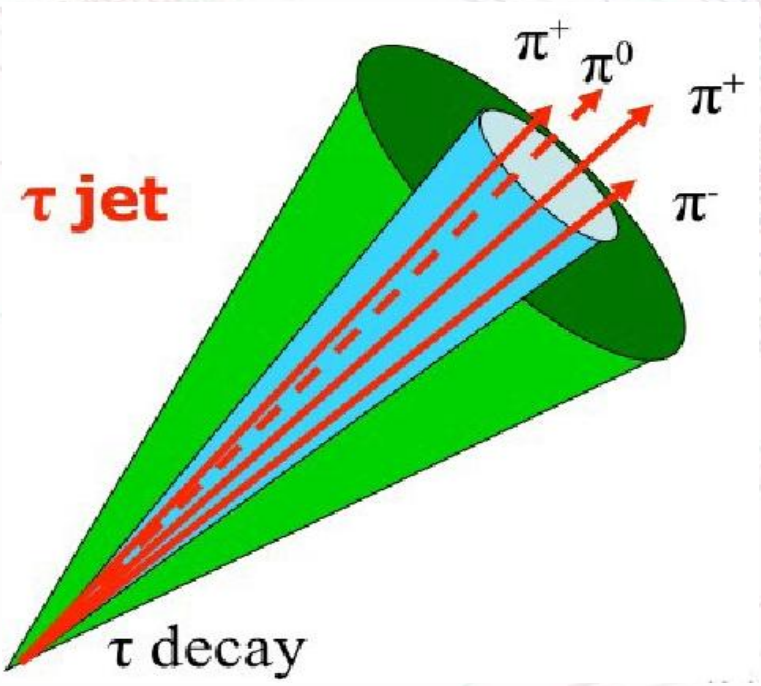
$Z \rightarrow \tau\tau$ cross section measurement

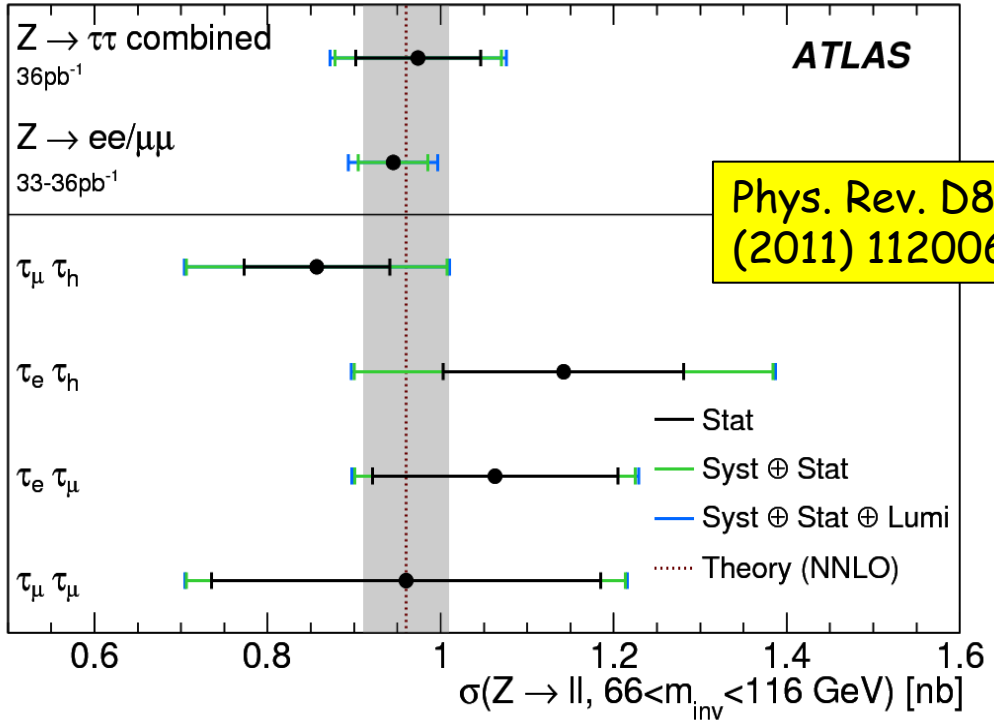
RECONSTRUCTION

- Building tau candidate objects using information from tracking detectors and calorimeter.

IDENTIFICATION

- Multivariate methods are used – identification is based on simple cuts, projective likelihood and boosted decision tree methods.

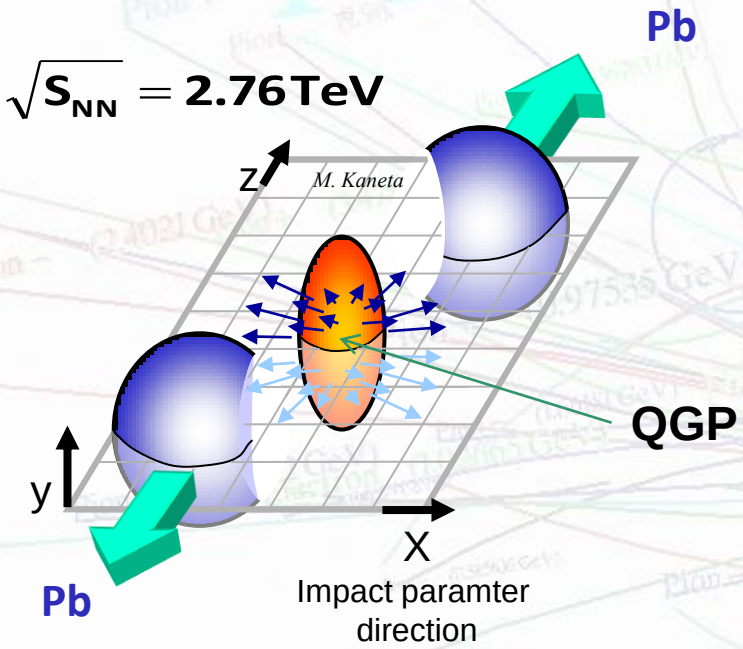




Published:

Phys. Rev. D 84, 112006 (2011) , ATLAS-CONF-2012-006, ATLAS-CONF-2011-010

Participation in the ATLAS Heavy Ion Program

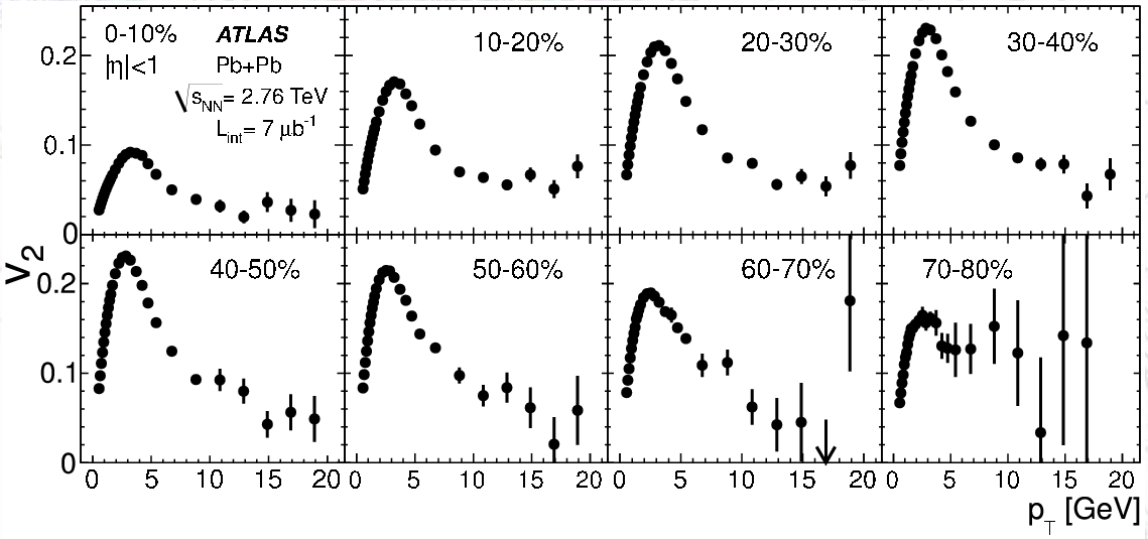


Significant contribution to:

- ❑ Software development for reconstruction of Pb-Pb collisions
- ❑ Coordination of prompt reconstruction
- ❑ Preparation of HLT Trigger menu
- ❑ Development of Data Quality code
- ❑ Successful completion of first and second Pb-Pb runs at the LHC:

Analysis of Pb-Pb data:

- Measurement of the azimuthal anisotropy at the LHC energy
  Phys.Lett. B707 (2012) 330
- Measurement of charged particle multiplicity in Pb-Pb collisions



Managment responsibilities
(past & current)

- convener of the Heavy Ion WG,
- convener of the Higgs WG,
- convener of the tau CP group,
- member of the CB chair advisory group,
- chair of the ATLAS Speakers Committee,
- member of theATLAS Publication Committee,
- member of the ATLAS Inner Detector Speakers Committee,
- convener of the ID Alignment group,
- convener of the TRT Monitoring and Control group,
- Software Development Coordinator for the Heavy Ion Working Group.

Difficulties:

No long-term funding schemes makes planning and far-future commitments difficult.

We struggle to attract PhD students:

1. Applied physics gives better perspectives,
2. Human lifespan of contemporary HEP exp'ts,
3. Lack of funds for longer stays at CERN during PhD studies (standard in many member states).

Senior staff positions suffer from:

1. No Long Term Attachment scheme,
2. Grant-dependent remuneration scheme making positions socially insecure.

Summary & Outlook

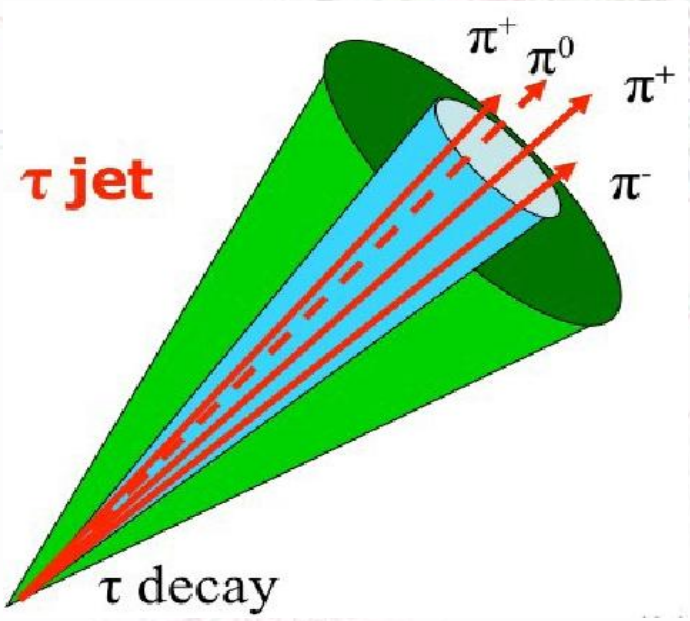
- Polish groups have been significantly contributing to detector construction and physics programme from the first days of the ATLAS project.
- It was possible thanks to long-lasting support from Polish government funding agencies.
- ATLAS has entered the phase of harvesting physics results in which we constantly increase our active participation.
- We've already made important commitements to future detector upgrades:
  - AFP (phase 1 upgrade)
  - Inner Tracker (phase 2 upgrade)
- We count on uninterrupted support from our funding agencies at the level allowing not only to maintain our current contribution but also extend our scientific potential.

BACKUP

Tau reconstruction and identification

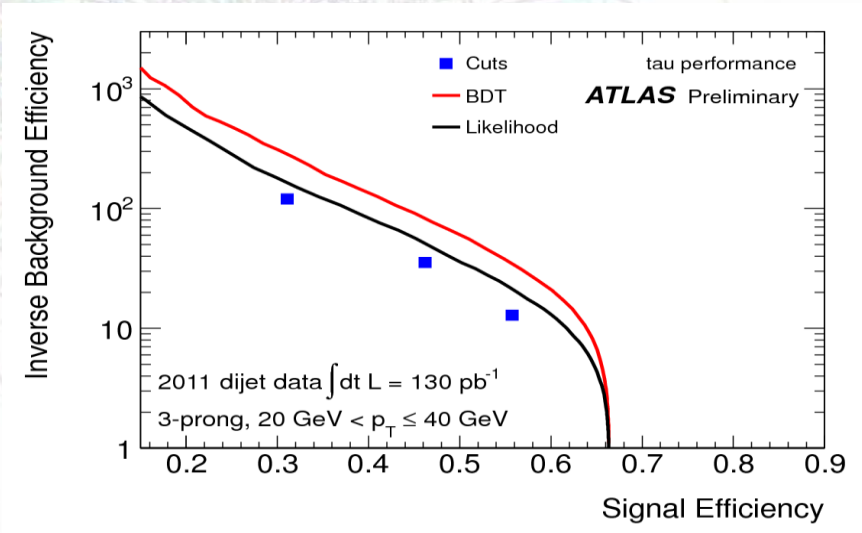
RECONSTRUCTION

- Building tau candidate objects using information from tracking detectors and calorimeter.
- Reconstruction provides very little rejection against QCD background - separate identification needed.



IDENTIFICATION

- Taus are difficult objects – we need a full power of many identification variables.
- Multivariate methods are used – identification is based on simple cuts, projective likelihood and boosted decision tree methods.

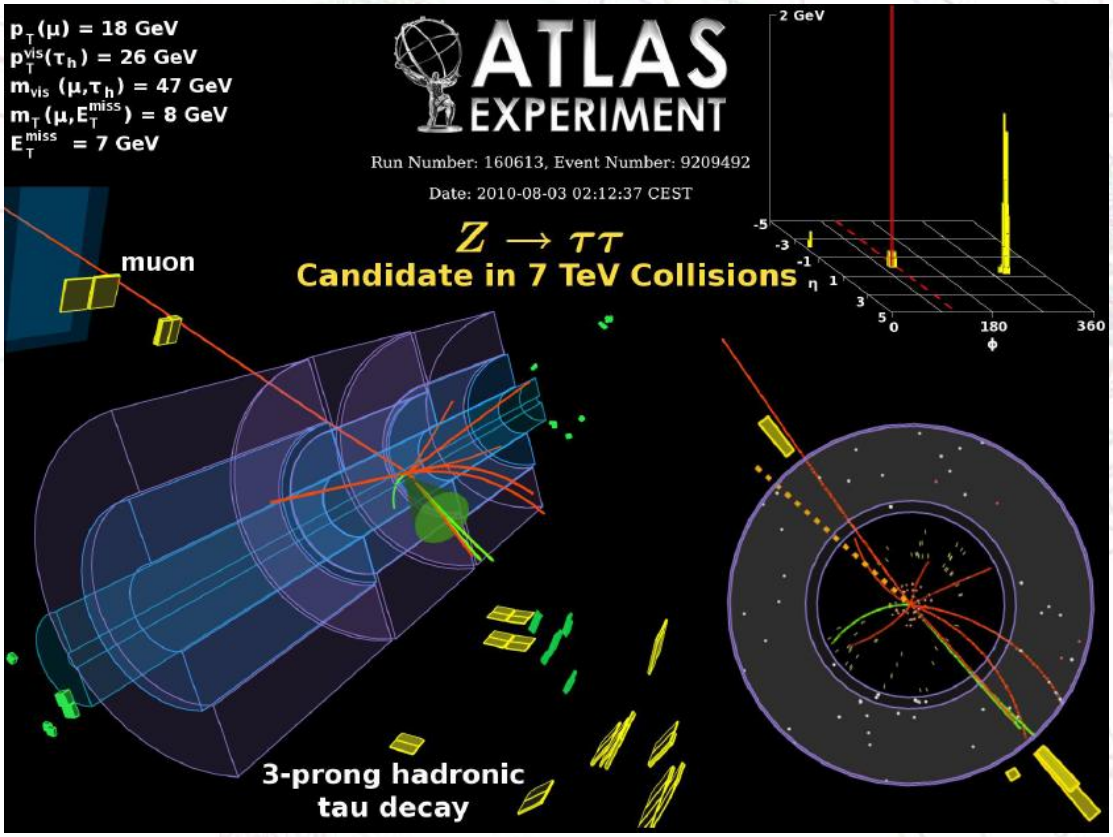


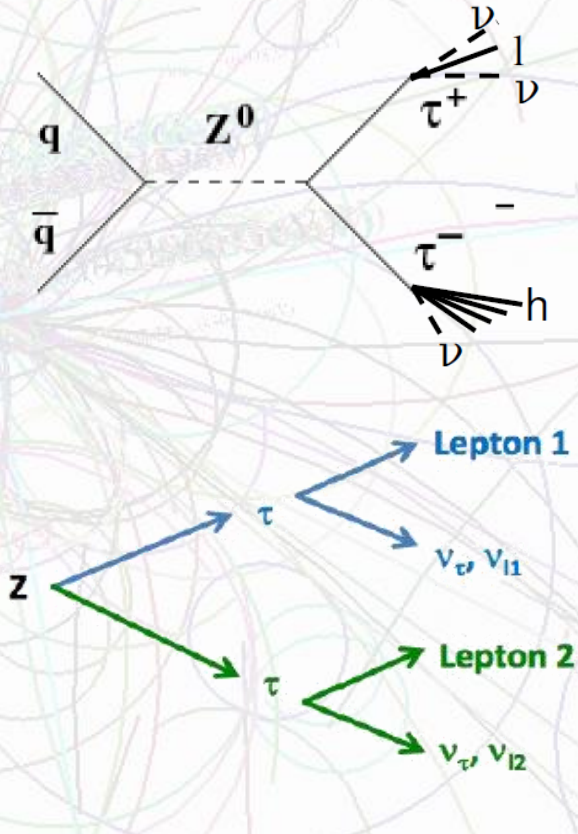
Published:
ATLAS-CONF-2011-152, ATLAS-CONF-2011-077, ATLAS-CONF-2010-059

$Z \rightarrow \tau\tau$ cross section measurement

Measurement of Z/W production cross section with taus in final states

- interesting itself as first time at so high energy
- background to Higgs boson and New Physics searches
- allows the measurement of the tau trigger, reconstruction, and identification efficiencies in data

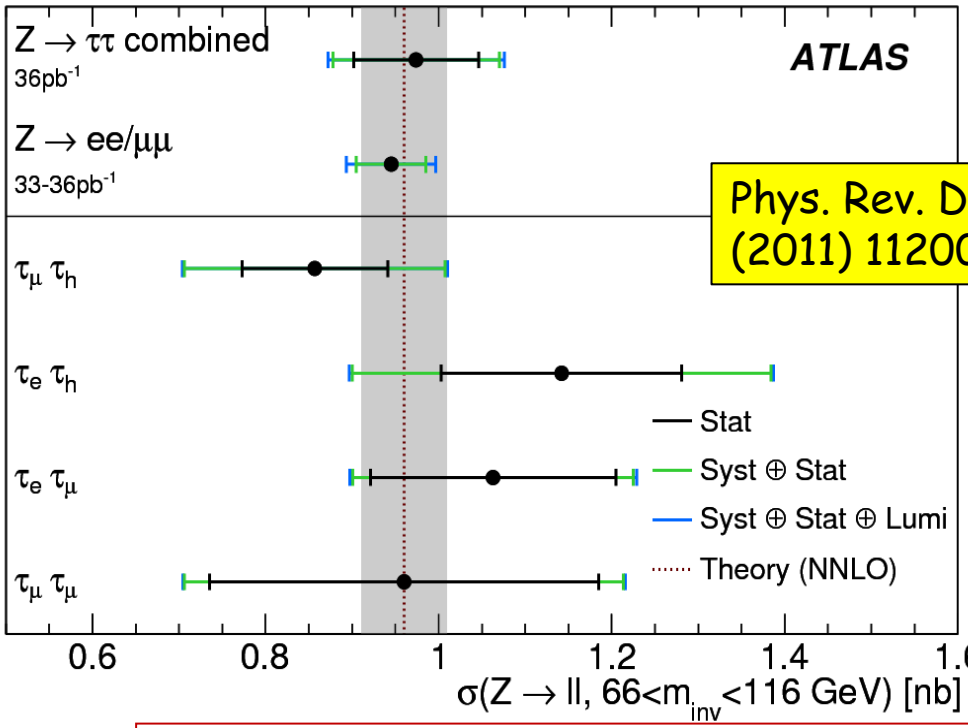




Measurement of $Z \rightarrow \tau\tau$ cross section with 36 pb-1 combining 4 final states:

τe-τhad , $\tau\mu$-τhad , τe-$\tau\mu$, $\tau\mu$-$\tau\mu$

$Z \rightarrow \tau\tau$ cross section measurement



Phys. Rev. D84 (2011) 112006

- QCD multijets production is dominant background due to its very large cross section
  - **crucial**: tau identification with high efficiency and rejection rate against fake tau candidates reconstructed from QCD multijets

$\sigma_{combined} = 0.97 \pm 0.07\ (stat.) \pm 0.07\ (syst.) \pm 0.03\ (lumi.)\ nb$

$\sigma_{theo} = 0.96 \pm 0.05\ nb$

Total cross section of $\gamma^*/Z \rightarrow \tau\tau$ in invariant mass of 66 < minv < 116 GeV in good agreement with theoretical expectation and CMS measurement

Published:
Phys. Rev. D 84, 112006 (2011) , ATLAS-CONF-2012-006, ATLAS-CONF-2011-010

W physics with ATLAS

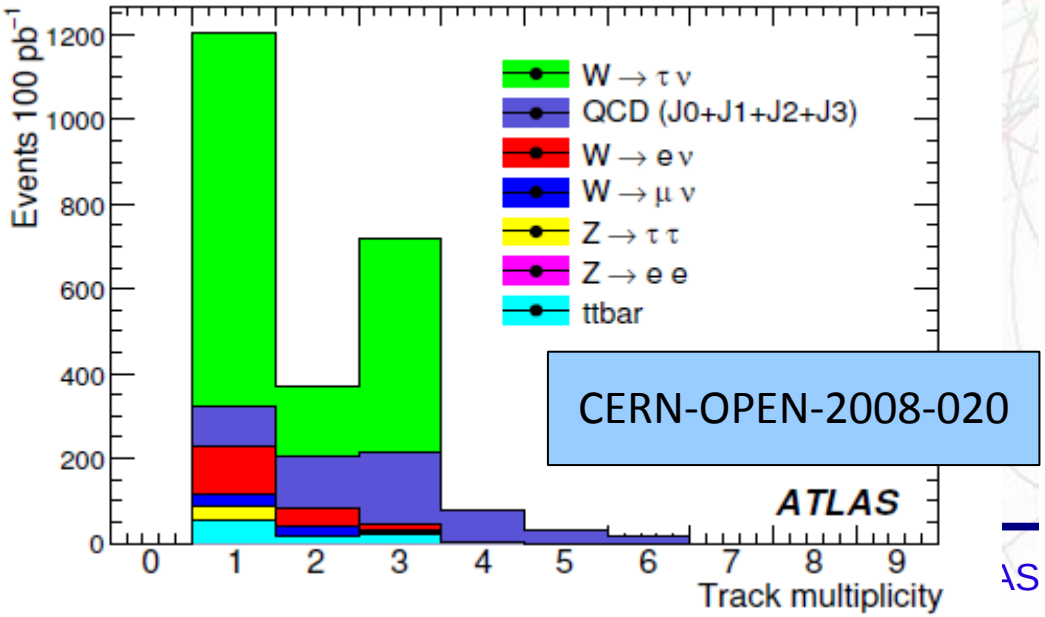
Estimation of W→τν observability potential

- The W-boson decays are the first sources of tau leptons in ATLAS
- Provides possibility to test and measure performance of tau reconstruction and identification
- Provides a contribution to the measurement of W cross section at so high energies
- Constitutes an important background to MSSM Higgs and SUSY processes

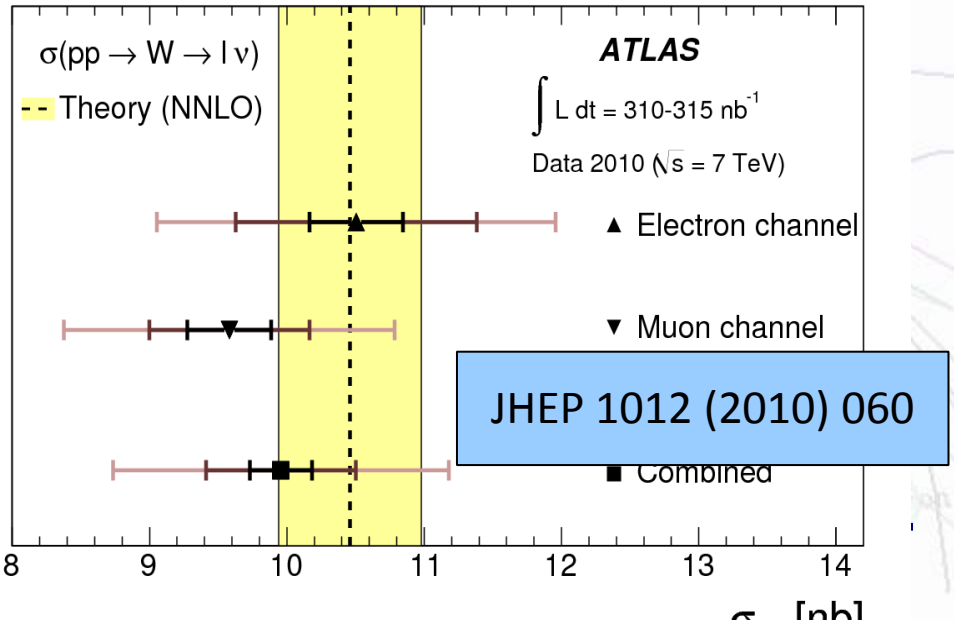
Measurement of W→eν cross-section in first data

- First such measurement at $\sqrt{s}$ = 7 TeV
- Possible to perform with very low statistics (0.3 pb^{-1})
- Great tool for measuring performance of detector and reconstruction software at very early stage of LHC running
- May be an important background process for New Physics
- Result in agreement with NNLO calculations:

$$10.51 \pm 0.34\,(\text{stat}) \pm 0.81\,(\text{syst}) \pm 1.16\,(\text{lumi})\ [\text{nb}]$$

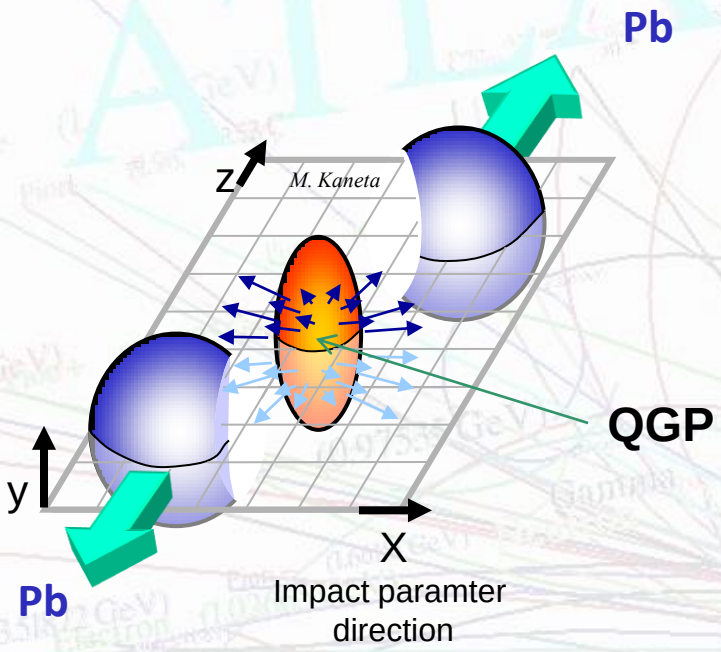


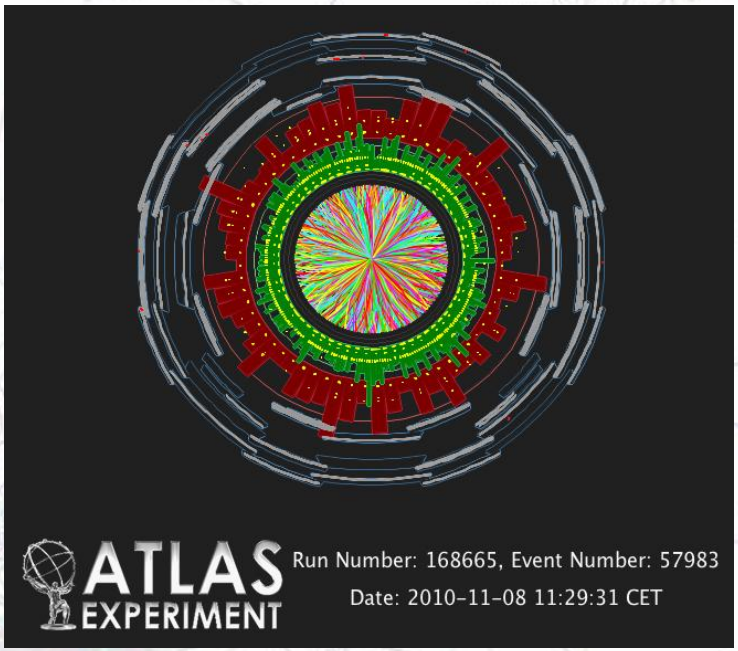
CERN-OPEN-2008-020



JHEP 1012 (2010) 060

ATLAS Heavy Ion Program

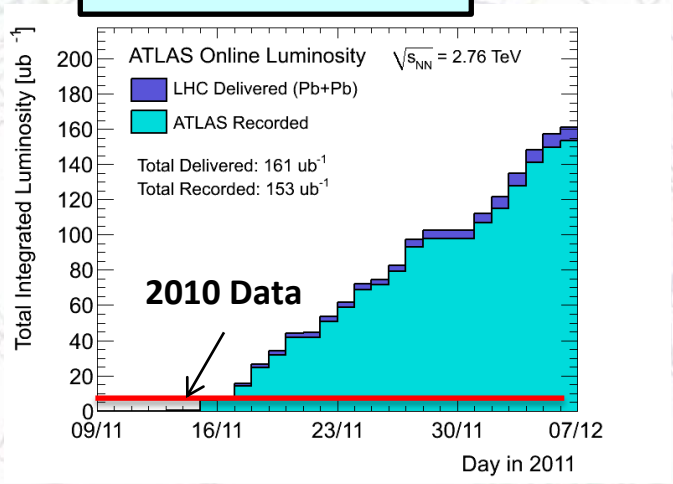




Heavy ion runs at LHC: $\sqrt{s_{NN}} = 2.76\,\text{TeV}$

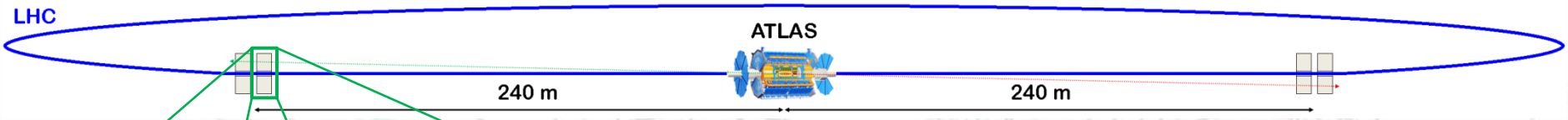
- Pb-Pb collisions at
- Excellent detector performance:
  Data recording efficiency > 95%
- Integrated luminosity of Pb-Pb data
  - ~9/μb in 2010
  - ~150/μb in 2011

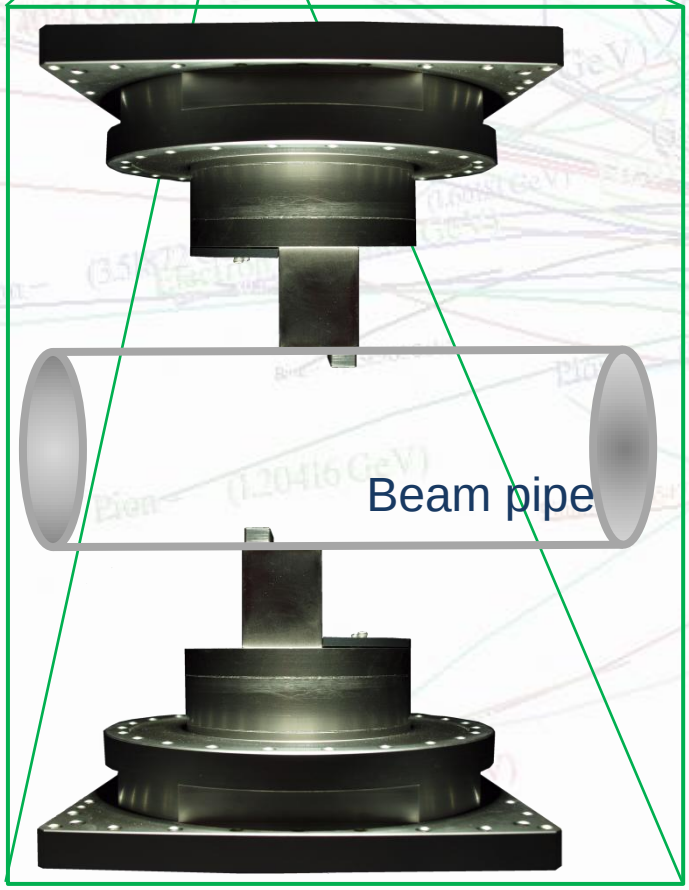
Pb-Pb run in 2011



ALFA - Absolute Luminosity For ATLAS

Measurement of the LHC absolute luminosity with pp elastic scattering at high β
Calibration of other ATLAS lumi detectors for relative lumi measurement





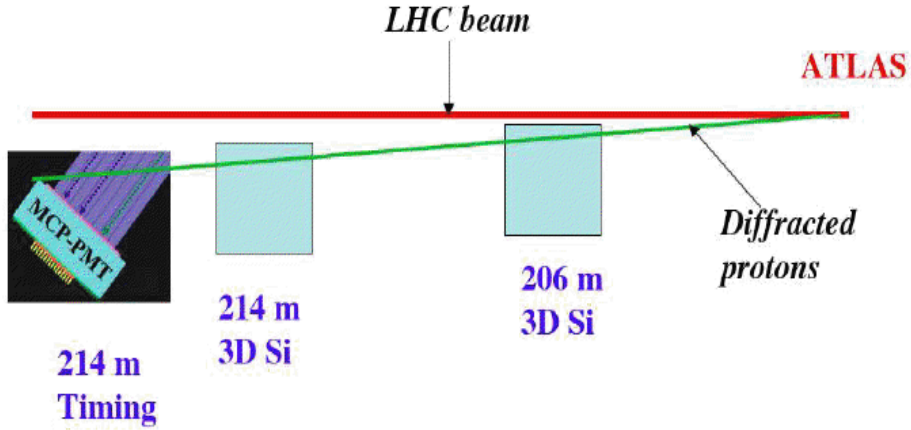
- **ONLINE:**
- design and implementation of standalone TDAQ system for beam tests in 2008-10 and integration wih central TDAQ of ATLAS
- design, implementation and maintenance of the online monitoring software
- supervision of data taking during high β run in 2011
- **OFFLINE:**
- scattered proton transport and event reconstruction
- energy unfolding
- event visualization

AFP - ATLAS Forward Physics

Extension of the ATLAS physics programme towards diffraction
Approved as a part of the ATLAS upgrade

AFP 210m detectors on both sides of the Interaction Point by the end of 2014
Data collected during normal LHC operation – many pp interactions per bunch crossing – pile-up

Requirement of very fast timing detectors for B/S separation
10 ps resolution of the timing detectors
Also: medical applications – ultra precise PET scanners



Cracow Forward Physics Group activities:

Diffractive W production – probing Pomeron structure

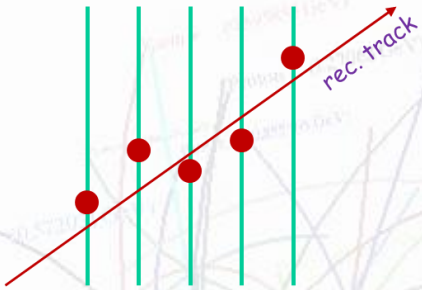
Central Exclusive Jet production – Tevatron limits improved by an order of magnitude

Optimisation of the masurement – best machine working mode

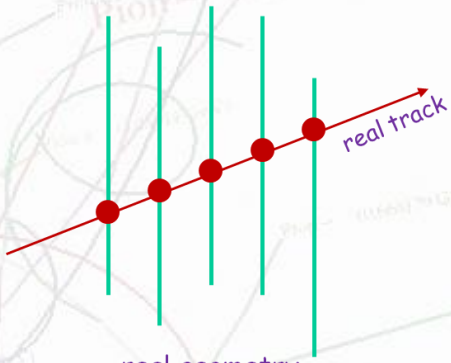
Background reduction – impact o the beam configurtion, pile-up considerations

Inner Detector alignment

Determination of over 700,000 DoF's of the ATLAS tracking system is realized by combination of Global and Local χ^2 methods.



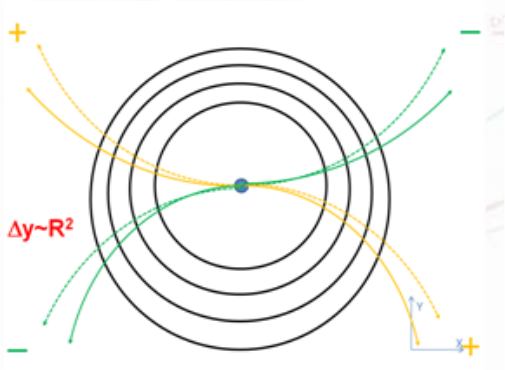
assumed geometry
compromised resolution (fit quality),
biasd parameters

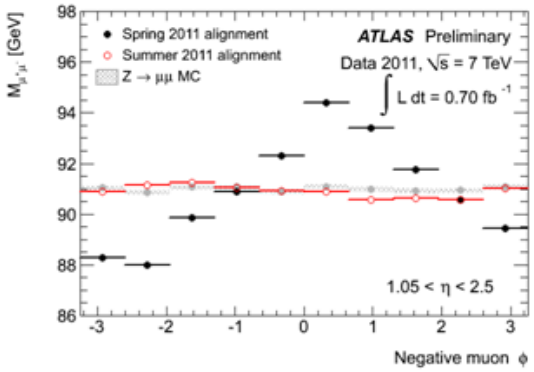


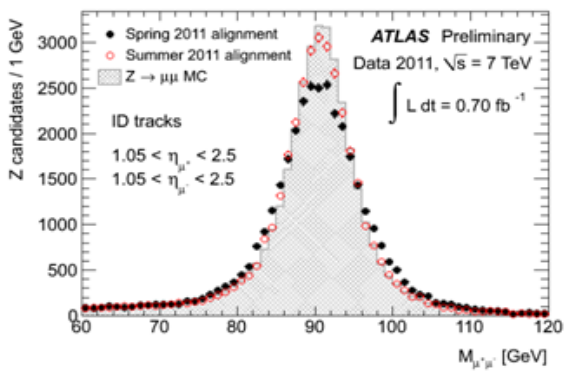
real geometry
optimal resolution,
unbiased parameters

Cracow group involvement:

- Development of the formalism,
- Software implementation from prototype to production,
- Simulated & real data challenges before LHC collisions,
- Subsequent alignment campaigns with p-p LHC data,
- Currently leading the team.

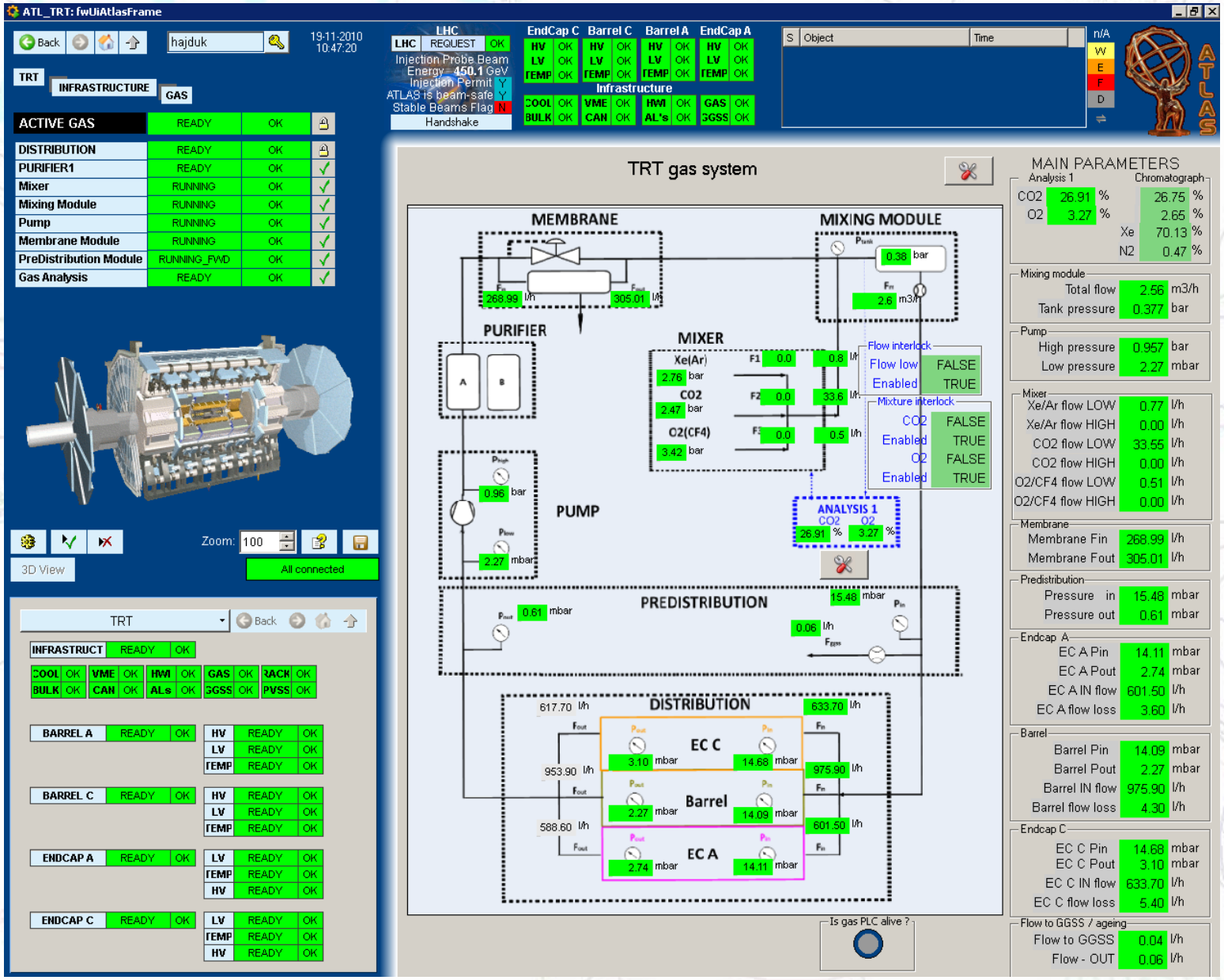






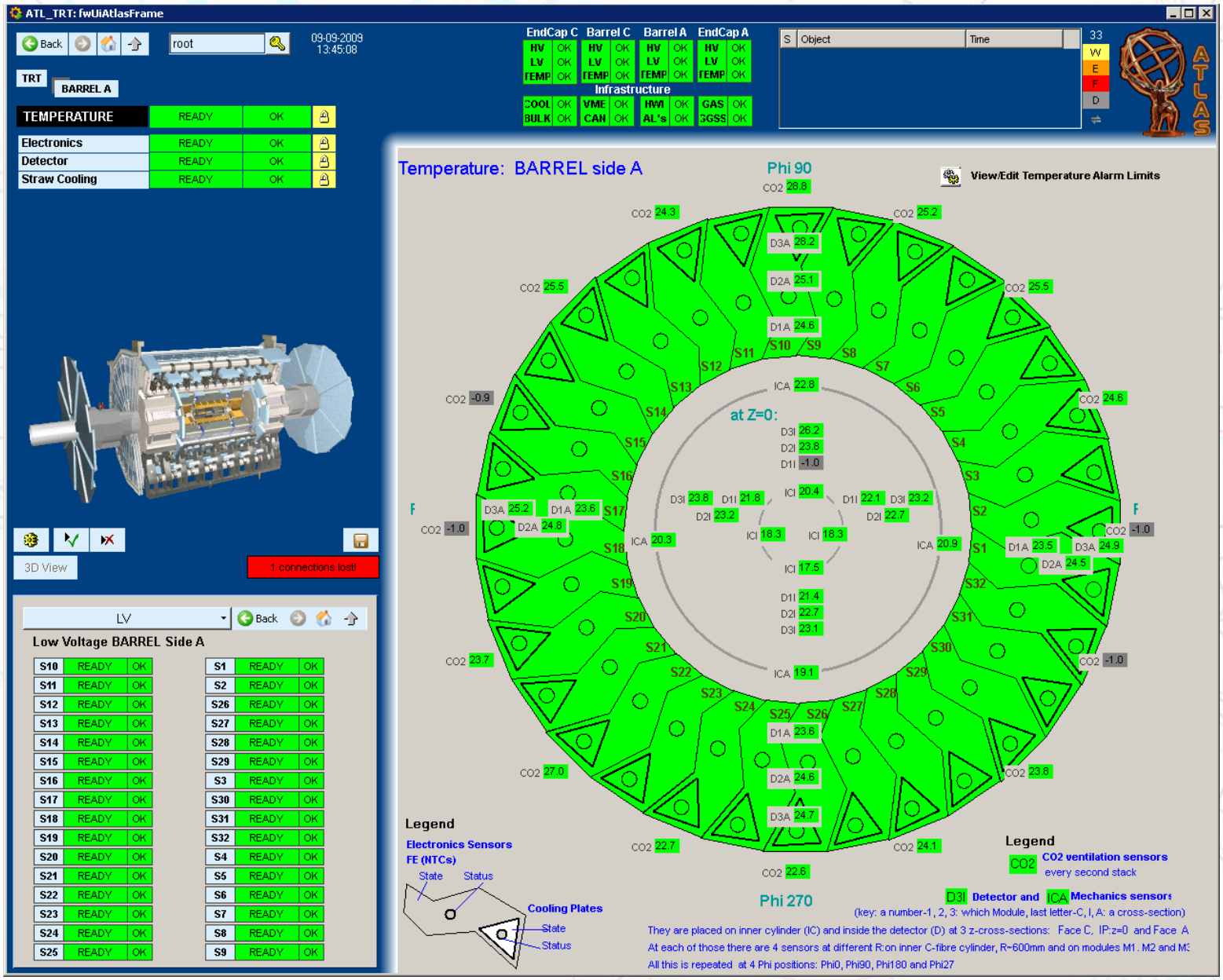
Major responsibility: theTRT DCS

Graphical User Interface to TRT DCS
Active-gas closed system with purification and recuperation
(3 m^3 of Xenon)



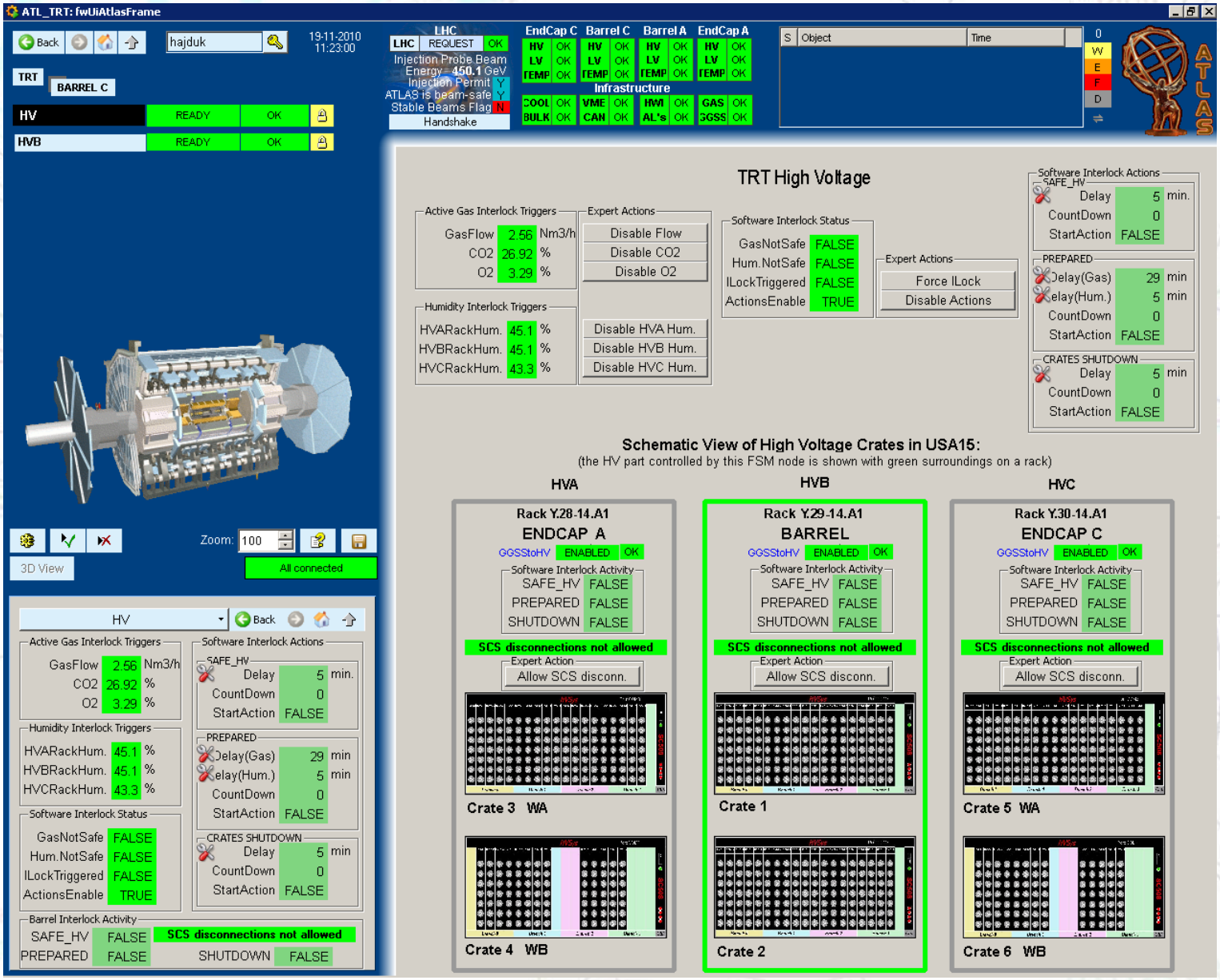
Major responsibilities in theTRT

Graphical User Interface to TRT DCS
An example panel giving temperature summary map



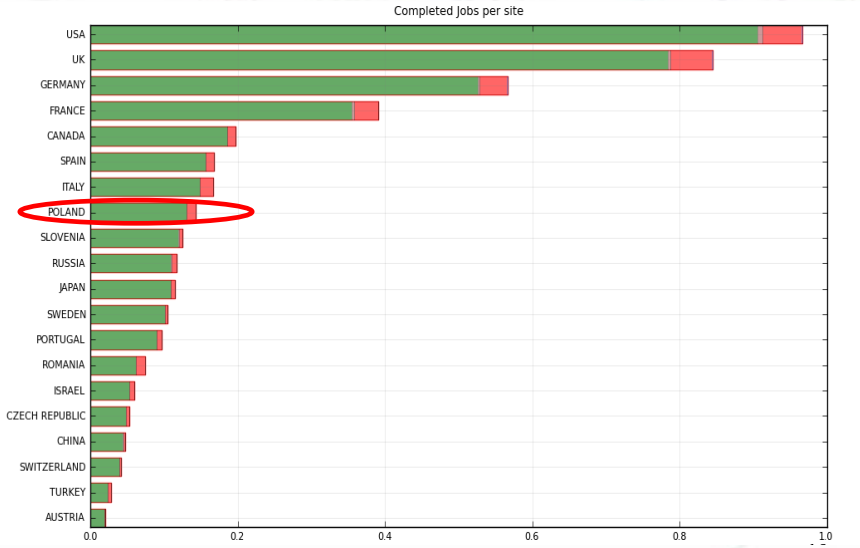
Major responsibilities in theTRT

Graphical User Interface to TRT DCS
Overview of TRT HV system
~ 2000 channels



ATLAS Production in Poland

ATLAS experiment is supported at 2 computing centers of the Polish Tier2 , ACK Cyfronet at Kraków and PSNC at Poznań. Both sites participated in Atlas computing production continuously in 2011.



Pledges	2010	2011	2012
CPU (HS06)	3,180	4,000	4,840
Disk (TB)	285	385	480

Installed	2010	2011	2012
CPU (HS06)	18,700	30,300	<57,500
Disk (TB)	215	345	>450

Delivered in 2011 more than 1.5% amount of pledged computing resources for ATLAS, delivering 2.9% CPU processing time in production and 2.1% in analysis, ranked 8 among Tier2 sites.